CLAIMS

1. A discharge lamp lighting apparatus, for controlling electric power supplied to a discharge lamp by a step-up/step-down converter comprising a transformer, a first switching element serially connected to the transformer on a side of a commercial ac power source, and a first diode and a first capacitor connected to the transformer on a load side, the discharge lamp lighting apparatus comprising:

zero-cross detection means for detecting zero-cross of voltage of said commercial ac power source;

a supplemental power circuit comprising a second diode connected to a junction between said transformer and said first switching element, a second capacitor for charging energy stored in a coil of said transformer on a side of said commercial ac power source via said second diode, and a second switching element, a third diode and an inductance through which the energy charged in the second capacitor is supplied to said discharge lamp; and

a control circuit that calculates a voltage cycle of said commercial ac power source based on an output from said zero-cross detection means and then operates said second switching element in said supplemental power circuit at a high frequency during a predetermined period of time around the zero-cross.

2. The discharge lamp lighting apparatus according to claim 1, further comprising current detection means for detecting current running through said discharge lamp; wherein said control circuit has calculation means for calculating a target current to be provided to said discharge lamp, said calculation means provides a constant target current during the period of time when the second switching element in said supplemental power circuit is operated at a high frequency and another target current of an arched waveform having peaks at around 90° and 270° of voltage of said commercial ac power source during the

period of time when said second switching element is not operated, and said control circuit controls the current running through said discharge lamp detected by said current detection means so as to make it equal to said calculated target current.

3. The discharge lamp lighting apparatus according to claim 2, wherein said target current of an arched waveform having peaks at around 90° and 270° of said commercial ac power source voltage during the period of time when the second switching element of said supplemental power circuit is not operated has a waveform of squared sinusoid.

4. The discharge lamp lighting apparatus according to claim 1, wherein said control circuit controls said supplemental power circuit to operate only during the period between 45° ahead and 45° behind the zero-cross of said commercial ac power source voltage or shorter, controls said constant, target current in the target current so as to make it equal to or less than half the peak value of said target current, and operates the second switching element in said supplemental power circuit at the same frequency and for the same or a shorter On-time as that for the first switching element in said step-up/step-down converter.

5. A discharge lamp lighting apparatus, for controlling electric power supplied to a discharge lamp by a step-up/step-down converter comprising a transformer, a first switching element serially connected to the transformer on a side of a commercial ac power source, and a first diode and a first capacitor connected to the transformer on a load side, the discharge lamp lighting apparatus comprising:

zero-cross detection means for detecting zero-cross of voltage of said commercial ac power source;

a supplemental power circuit comprising a second capacitor installed on a side of said commercial ac power source which is charged via a second diode, a first inductance and the first switching element in the step-up/step-down converter, and supplies energy stored in the second capacitor to said discharge lamp via a third diode, second inductance and second switching element; and

a control circuit that calculates a voltage cycle of said commercial ac power source based on an output from said zero-cross detection means and then operates said second switching element in said supplemental power circuit at a high frequency during a predetermined period of time around the zero-cross.

6. The discharge lamp lighting apparatus according to claim 1, further comprising current detection means for detecting the current running through said discharge lamp; wherein said control circuit switches the second switching element in said supplemental power circuit at a high frequency over the whole cycles of said commercial ac power source voltage until said current detection means detects current running through said discharge lamp after lighting up of said discharge lamp.

7. The discharge lamp lighting apparatus according to claim 1, further comprising voltage detection means for detecting voltage of said commercial ac power source; wherein said second switching element in said supplemental power circuit is switched at a high frequency when said commercial ac power source voltage is determined to be lower than a normal voltage.

8. A discharge lamp lighting apparatus, for controlling electric power supplied to a discharge lamp by a step-up/step-down converter comprising a transformer, a first switching element serially connected to said transformer on a side of a commercial ac power source, and a first diode and a first capacitor connected to the transformer on a load side, the discharge lamp lighting apparatus comprising:

zero-cross detection means for detecting zero-cross of voltage of said commercial ac power source;

a supplemental power circuit comprising a second diode connected to a junction between said transformer and said first switching element, a second capacitor for charging energy stored in a coil of said transformer on a side of said commercial ac power source via said second diode, and a second switching element, a third diode and an inductance through which the energy stored in the second capacitor is supplied to said discharge lamp; and

a control circuit that operates said second switching element in said supplemental power circuit at the same high frequency as that for the first switching element in said step-up/step-down converter, with an On-time shorter by a predetermined time than the On-time of said first switching element, over whole cycles of said commercial ac power source.

9. The discharge lamp lighting apparatus according to claim 8, further comprising current detection means for detecting current running through said discharge lamp; wherein said control circuit has calculation means for calculating a target current to be provided to said discharge lamp to make a target current of an arched waveform having peaks at around 90° and 270° of said commercial ac power source voltage and almost flat portions around zero-cross, and controls current running through the discharge lamp, which is detected by said current detection means, so as to make it equal to said calculated target current.

10. A lamp apparatus having the discharge lamp lighting apparatus according to claim 1.

11. The discharge lamp lighting apparatus according to claim 5, further comprising current detection means for detecting the current running through said discharge lamp; wherein said control circuit switches the second switching element in said supplemental power circuit at a high frequency over the whole cycles of said commercial ac power source voltage until said current detection means detects current running through said discharge lamp after lighting up of said discharge lamp.

12. The discharge lamp lighting apparatus according to claim 5, further comprising voltage detection means for detecting voltage of said commercial ac power source; wherein said second switching element in said supplemental power circuit is switched at a high frequency when said commercial ac power source voltage is determined to be lower than a normal voltage.

13. A lamp apparatus having the discharge lamp lighting apparatus according to claim 2.

14. A lamp apparatus having the discharge lamp lighting apparatus according to claim 3.

15. A lamp apparatus having the discharge lamp lighting apparatus according to claim 4.

16. A lamp apparatus having the discharge lamp lighting apparatus according to claim 5.

17. A lamp apparatus having the discharge lamp lighting apparatus according to claim 6.

18. A lamp apparatus having the discharge lamp lighting apparatus according to claim 7.

19. A lamp apparatus having the discharge lamp lighting apparatus according to claim 8.

20. A lamp apparatus having the discharge lamp lighting apparatus according to claim 9.